Check List the journal of biodiversity data

NOTES ON GEOGRAPHIC DISTRIBUTION

Check List 15 (6): 1153–1160
https://doi.org/10.15560/15.6.1153

PENSOFT

# New occurrences of small aquatic duckweeds (Araceae, Lemnoideae) in Maranhão state, northeastern Brazil

Alessandro Wagner Coelho Ferreira[1], Miguel Sena de Oliveira[2], Wagner Ribeiro da Silva Junior[1], Ivanilza Moreira Andrade[3], Marcus Alberto Nadruz Coelho[4], Hermeson Cassiano de Oliveira[5], Simon Joseph Mayo[6]

**1** Universidade Federal do Maranhão, Departamento de Biologia, Cidade Universitária Dom Delgado, Av. dos Portugueses, 1966, Bacanga, São Luís, MA, CEP 65080-805, Brazil. **2** Universidade Estadual do Maranhão, Programa de Pós-Graduação em Biodiversidade, Ambiente e Saúde, Praça Duque de Caxias, s/n, Morro do Alecrim, Caxias, MA, CEP 65604-090, Brazil. **3** Universidade Federal do Piauí, Herbário Delta do Parnaíba, Campus Ministro Reis Velloso, Av. São Sebastião, 2819, Parnaíba, PI, CEP 64202-020, Brazil. **4** Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Diretoria de Pesquisas, Rua Pacheco Leão 915, Rio de Janeiro, RJ, CEP 22460-030, Brazil. **5** Universidade Estadual do Piauí, Campus Heróis do Jenipapo, Av. Sto. Antônio s/n, Bairro São Luis, Campo Maior, PI, CEP 64280-000, Brazil. **6** Royal Botanic Gardens, Herbarium, Kew, Richmond, Surrey, TW9 3AE, United Kingdom.
**Corresponding author:** Hermeson Cassiano de Oliveira, hermeson123@gmail.com

## Abstract

This study presents the first records for Maranhão state, northeastern Brazil, of the duckweeds *Lemna valdiviana* Phil., *Wolffia brasiliensis* Wedd. and *Wolffiella lingulata* (Hegelm.) Hegelm. The species were collected in a survey of water bodies in the muncipalities of Caxias, Igarapé do Meio and São João do Sóter. Descriptions, illustrations, maps, georeferenced specimen citations and an identification key are provided. These new records contribute to the expansion of the knowledge of the Maranhão flora and the geographic distribution of the Lemnoideae of the Northeast region of Brazil.

## Keywords

Amazonia Maranhense, aquatic plants, Araceae, Cerrado Maranhense.

**Academic editor:** Juliana de Paula-Souza | Received 14 September 2019 | Accepted 12 December 2019 | Published 31 December 2019

**Citation:** Ferreira AWC, Oliveira MS, Silva Junior WR, Andrade IM, Coelho MAN, Oliveira HC, Mayo SJ (0000) New occurrences of small aquatic duckweeds (Araceae, Lemnoideae) in Maranhão state, northeastern Brazil. Check List 15 (6): 1153–1160. https://doi.org/10.15560/15.6.1153

## Introduction

The family Araceae Juss. has 144 genera (34 endemic to the Americas) and 3,645 species (Boyce and Croat 2011 onwards). It has a cosmopolitan distribution (except in Antarctica) and most of the species occur in the tropics (Grayum 1990; Mayo et al. 1997; Boyce and Croat 2011 onwards).

Important characteristics of Araceae species are their aerial (procumbent or scandent) or subterranean (corms, rhizomatous or tuberous) stems, entire or compound leaves that are sheathed at the base or along the petiole, spadix inflorescence type with a long or short peduncle, surrounded by a spathe that may be larger or smaller than the spadix, and uni- or bisexual flowers (Mayo et al. 1997; Coelho 2010, 2018). They may be epiphytic, hemiepiphytic, rupicolous, terrestrial, palustral, or aquatic, and in Brazil they are found mainly in humid lowland and montane areas of the Atlantic and Amazonian Forests as well as in Restingas, Campos, and

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on rock outcrops (Mayo et al. 1997; Coelho et al. 2015, Coelho 2018).

In Brazil, about 50% of epiphytic or hemiepiphytic Araceae species occur in the Atlantic Forest Domain and are among the most species-rich families in the Amazonian Domain (BFG 2015). Although fewer in number, there are species adapted to the seasonally dry climate of the Cerrado, Caatinga, and Campos Rupestres (Mayo et al. 1997; Cansanção 2008). There are about 511 species of Araceae in Brazil distributed in 38 genera, among which are the aquatic species of subfamily Lemnoideae (Pott 2002; Boyce and Croat 2011 onwards; Coelho et al. 2015; Flora do Brasil 2019).

Since the phylogenetic study of Cabrera et al. (2008), the Lemnaceae Gray have been included in the Araceae as subfamily Lemnoideae Engl. Cabrera et al. recognized nine subfamilies of Araceae: Gymnostachydoideae Bogner & Nicolson, Orontioideae Mayo, Bogner & P.C. Boyce, Lemnoideae Engl., Pothoideae Engl., Monsteroideae Engl., Lasioideae Engl., Zamioculcadoideae Bogner & Hesse, Calloideae Endl., and Aroideae.

The Lemnoideae is a cosmopolitan subfamily, not occurring in the Arctic and Antarctica, and rare in places with low rainfall (Landolt 1996). It has 38 species distributed in five genera: *Landoltia* Les & D.J. Crawford, *Lemna* L., *Spirodela* Schleid., *Wolffia* Horkel ex Schleid., and *Wolffiella* Hegelm. (Les et al. 2002; Armstrong 2011 updated 2018; Appenroth et al. 2013).

Commonly known as duckweeds or water lentils, Lemnoideae species are important in aquatic food chains (Pott and Cervi 1999). They include the smallest angiosperms in the world and *Wolffia* includes the species with the smallest flowers (Daubs 1965). As there is no differentiation between stem and leaf, the vegetative body is referred to as a frond (Pott and Cervi 1999). The floral structures are very reduced and difficult to interpret. According to Landolt (1996) and Bogner (2009), duckweed flowers are basically bisexual, but in species having more than one stamen in the "flower", unisexual male flowers are also said to be present. Due to their small size and morphological variation, lemnoids are difficult to study and some botanical terms used to describe them are different from those commonly used in Araceae and other families; consequently, they are often overlooked.

Maranhão has a rich and ecotonal flora, influenced by those of Amazonia, the Cerrado, and Caatinga (Silva-Moraes et al. 2019). Despite this, Maranhão has been little studied in floristic surveys. Recent studies have demonstrated several new species records for the flora of the state, indicating the need for further botanical surveys (Ferreira et al. 2017; Ferreira et al. 2018; Guarçoni et al. 2018a, 2018b; Silva Junior et al. 2018).

Eighteen genera and 34 species of Araceae have been recorded in Maranhão by Flora do Brasil (2019) but none for subfamily Lemnoideae, though Landolt (1986) previously recorded *Lemna aequinoctialis* Welw. in the state. In the present work, we report the first records of three more species of these aquatic Araceae for the flora of Maranhão: *Lemna valdiviana* Phil., *Wolffia brasiliensis* Wedd. and *Wolffiella lingulata* (Hegelm.) Hegelm. Morphological descriptions, illustrations, and an identification key for the species found in Maranhão are presented, as well as a map showing the locations of the new records. These are also the first records of *Wolffia* and *Wolffiella* for the state of Maranhão.

## Methods

**Study region.** The state of Maranhão has 217 municipalities, occupies an area of 331,983 km², and is the second largest state in the Northeast Region of Brazil. It is located on the northwestern part of the Northeast Region and borders the Atlantic Ocean (to the north) and the state of Piauí (to the east), Tocantins (to the south and southwest), and Pará (to the west). Maranhão is also part of the so-called Brazilian Legal Amazon, according to Law no. 1806, from January 6, 1953 (Diário Oficial da União 1953). The physiognomy of its vegetation has ecotonal characteristics, since it is located on a transition area between Amazonia (Northern Region of Brazil), the Cerrado (Central-West Region) and the semi-arid Caatinga (Northeastern Region). The vegetational transitions with the Amazon Forest occur in the western part of the state (Amazônia Maranhense), while the north is characterized by floodplains, mangroves, and restingas (Costa 1982; IBGE 2019). The Cerrado (Cerrado Maranhense) extends from the entire southern region to the northeast of the state, with the Cerradão physiognomy as dominant. The Cocais are a man-made vegetational physiognomy located in the central region, while the Caatinga occurs only in small areas in the eastern region (Silva-Moraes et al. 2019).

According to the classification of Köppen (1948), Maranhão has the Am (Tropical Monsoon) and Aw/As (Tropical Savanna) climate types, transitioning between the Tropical Rainforest climate of the Amazon and the Hot Semi-Arid climate of the driest parts of the Northeast Region. The average annual temperature varies between 22 and 27 °C and average annual rainfall varies between 800 and 2,800 mm (IMESC 2008). The dry period varies from five to six months, from June to November/December, when the water deficit reaches 150–300 mm (Golfari 1980; Jesus et al. 1986), with the driest period between July and October and the highest concentration of rainfall between February and March (IMESC 2008). The elevation rises overall from the north to the south of Maranhão. Altitudes reach 50 m in northern Maranhão, vary between 200 and 400 m in the Central Maranhense region, and attain 800 m in the south (Silva-Moraes et al. 2019). The geology is composed mainly of sedimentary rocks of the Barreiras and Itapecuru Formations (IDESP 1995; Feitosa 2006).

**Data collection.** The Araceae specimens were collected during fieldwork on the Maranhão flora from July 2018

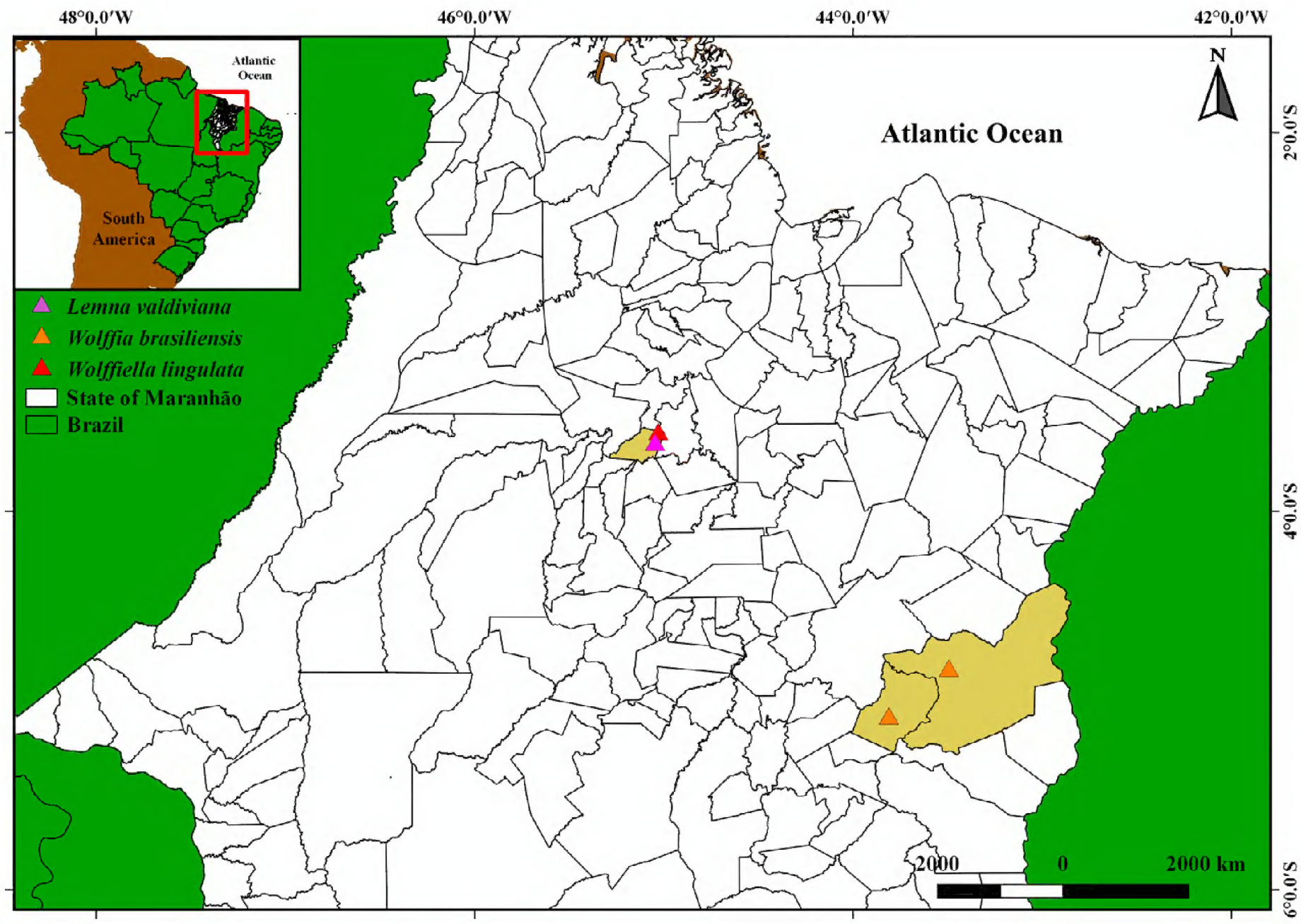


**Figure 1.** Collection sites of *Lemna valdiviana*, *Wolffia brasiliensis* and *Wolffiella lingulata* in the state of Maranhão, northeast Brazil.

to March 2019, in areas of the Amazônia Maranhense (municipality of Igarapé do Meio, in a marshy area along the Puraquéu stream) and Cerrado Maranhense (municipalities of Caxias (Riacho Guarimã) and São João do Sóter (Rio Buriti)) vegetation types (Fig. 1).

Species identifications were carried out with the aid of a binocular stereomicroscope Stemi DV4 ZEISS® and specialized literature (Hegelmaier 1878; Landolt 1986; Pott and Cervi 1999; Pott 2002; Andrade et al. 2013; Pereira et al. 2016; Freitas et al. 2017; Coelho 2018; Lourenço and Bove 2019) and also by comparison with herbarium specimens identified and deposited in the herbaria of NY, K, RB, MO, and BHCB (acronyms according to Thiers 2019). The names of the authors follow Brummitt and Powell (1992). The geographic distribution of species follows Moura-Júnior (2013) and the online databases Flora do Brasil (2019), SpeciesLink (2019), and Tropicos (2019). The collected specimens were fixed in 70% alcohol, and those that were made into dried herbarium specimens were prepared using the standard botanical protocols described by Fidalgo and Bononi (1989). The dried specimens were incorporated into the Herbário do Maranhão (MAR), located in the Department of Biology of the Universidade Federal do Maranhão, São Luís, Maranhão, Brazil and at the Herbário of Universidade Estadual do Piauí, Campus Heróis do Jenipapo (HUESPI) in Campo Maior, Piauí, Brazil.

The geographic distribution map of the new records was made with QGIS v. 2.18.12 using the SIRGAS 2000 datum. The plant images were captured with digital cameras and the SteeO Discovery V8 Stereomicroscope Zeiss®, coupled to an AxioCam camera ICc1 Zeiss®, and edited using Adobe Photoshop® CS5 v. 12.0 (Adobe Systems Incorporated).

## Results

In the study area, three species of Lemnoideae were identified, in addition to the previous record of *Lemna aequinoctialis* (Landolt 1986): *Lemna valdiviana* Phil., *Wolffia brasiliensis* Wedd., and *Wolffiella lingulata* (Hegelm.) Hegelm. According to the specialized literature corroborated by the database of Flora do Brasil (2019), these three species are new records for the state of Maranhão, as well as the first records of *Wolffia* and *Wolffiela* for this state.

### Taxonomic treatment

**Identification key for the species of Lemnoideae from the Maranhão state, Brazil**

1. Plant with one root per frond. Fronds in groups of 2–4
   2. Frond with a single vein ..... *Lemna valdiviana**
   2′. Frond with three veins ..... *Lemna aequinoctialis* (record by Landolt 1986: 308)
1′. Plant without roots. Fronds free and single or in groups of 2.

3. Frond ovate to orbiculate, a single papilla present on the midline of the upper side; without elongated cells present between the midline and edge ..... ..... *Wolffia brasiliensis*

3′. Frond tongue-shaped, papilla absent in the midline of the upper side; elongated cells present between the midline and edge ..... *Wolffiella lingulata*

**Lemna minuta* can be confused with *L. valdiviana* but is distinguished by the absence of veins in the frond.

***Lemna valdiviana* Phil.** Linnaea 33: 239, 1864.
Figure 2A, B

**Type.** Chile • Provinz Valdivia, San Juan, Tremblade-rilla; 1861; R.A. Phillipi s.n. (STU 178735/20111 [photo!], lectotype, selected by Landolt [1986]).

**Materials examined.** Brazil • Maranhão, Igarapé do Meio, Puraquéu stream bridge; 03°35′S, 045°01′W; 6 Mar. 2019; W.R. Silva Junior, A.W.C. Ferreira 300 (MAR 11532). • same locality; 03°35′S, 045°01′W; 6. Mar. 2019; W.R. Silva Junior, A.W.C. Ferreira 301 (MAR 11533).

**Identification.** Free-floating aquatic plant. Root 1 per frond, 11–22 mm long. Fronds united in groups of 2–4, oblong, planar, sessile, light green, 1–5 mm × 0.8–2.3 mm, twice as long as wide, with a single papilla on the midline of the upper side, median rib 0.8–4.8 mm long present between node and frond apex. Flowers and fruits not observed.

***Wolffia brasiliensis* Wedd.** Ann. Sci. Nat. Bot. Ser. III 12: 170, 1849.
Figure 2C

**Type.** Brazil • Provincia de Matto Grosso, Villa Maria; July 1845; M.H.A. Weddell (STU lectotype; L, MO! isolectotypes).

**Materials examined.** Brazil • Maranhão, Caxias, Primavera Village, Guarimã stream; 04°50′S, 043°29′W; 18 Jul. 2018; M.S. Oliveira, A.W.C. Ferreira 132 (MAR 11534). • same locality; 18 Jul. 2018; M.S. Oliveira, A.W.C. Ferreira 133 (HUESPI 1508). • São João do Sóter, Buriti stream spring; 05°05′S, 043°48′W; 25 Jul. 2018; M.S. Oliveira, A.W.C. Ferreira 134 (MAR 11535). • same locality; 25 Jul. 2018; M.S. Oliveira, A.W.C. Ferreira 135 (HUESPI 1509).

**Identification.** Free, surface-floating aquatic plant, roots absent. Fronds single or united in pairs, green, covered with light brown pigment, ovoid to suborbicular on abaxial side and flattened on adaxial side, 1.0 mm × 0.7 mm, longer than wide; central adaxial region of the frond with conical papilla, 0.1–0.8 mm long. Flowers and fruits not observed.

***Wolffiella lingulata* (Hegelm.) Hegelm.**, Bot. Jarb. 21: 303, 1895.
Figure 2D

**Type.** Mexico • May 1868; L. Hahn s.n. (STU, holotype).

**Materials examined.** Brazil • Maranhão, Igarapé do Meio, Puraquéu stream bridge; 03°35′S, 045°01′W; 06 Mar. 2019; W.R. Silva Junior, A.W.C. Ferreira 302 (MAR 11536). • same locality; 03°35′S, 045°01′W; 06 Mar. 2019; W.R. Silva Junior, A.W.C. Ferreira 303 (MAR 11537).

**Identification.** Free-floating, submersed aquatic plant, stemless, roots absent. Fronds green, floating in groups of 2 (rarely 3), tongue-shaped, falcate, membranous, distinct in size, with raised lateral margins, 3.2–4.9 × 1.6-3.5 mm, 1.2–2.5 times longer than wide, base slightly oblique, truncate, apex rounded or sometimes narrower than base, midline region with elongated cells. Flowers and fruits not observed.

## Discussion

*Lemna* is characterized by the presence of only one root per frond with a cylindrical membrane at the root base and with individuals either floating on the water surface or submerged. The fronds are flat or gibbous, elliptic to obovate, with or without papillae on the adaxial surface, usually with 1–5 evident or obscure veins. The inflorescence has two male flowers and one female flower, surrounded by a membrane with a lateral opening (Flora of Brazil 2019). This genus is distributed in North America (USA), Central America (Guatemala, Honduras and Mexico), South America (Brazil), and Asia (China) (Pott 2002; Tropicos 2019). It is represented by 13 species many of which are associated with human activity. Four species are found in Brazil: *Lemna aequinoctialis* Welw., *L. gibba* L., *L. minuta* Kunth, and *L. valdiviana* Phil. (Flora of Brazil 2019).

*Lemna valdiviana* occurs throughout the American continents (Landolt, 1986; Tropicos 2019). In Brazil, there are confirmed records of this species in the following major regions: North (Amazonas), Northeast (Bahia, Ceará, Paraíba, Pernambuco and Piauí), Central-West (Mato Grosso and Mato Grosso do Sul), South (Paraná, Rio Grande do Sul and Santa Catarina), and Southeast (Espírito Santo, Rio de Janeiro and São Paulo) (Pott 2002; Pereira et al. 2016; BFG 2018). In Maranhão state, the species was found in the municipality of Igarapé do Meio, floating by the banks of a bridge over the Puraquéu Igarapé, a tributary of the Rio Mearim that drains the area of the town of Igarapé do Meio (Correia Filho et al. 2011). It was associated with *Wollfiella lingulata*, *Azolla* sp., *Eichhornia crassipes* (Mart.) Solms, *Pistia stratiotes* L., and *Salvinia* sp.

Based on the information available in the database Specieslink (2019), the nearest records of *L. valdiviana* to that in Igarapé do Meio are about 776 km to the north (Parque Nacional Boqueirão da Onça), 370 km to the south (Fazendinha, Parnaíba, Piauí, Brazil), and 2,220 km to the east (Amazonas, Brazil) (Fig. 1).

The record of the occurrence of *L. valdiviana* in Maranhão extends the knowledge of its geographical distribution and will also aid studies regarding its potential

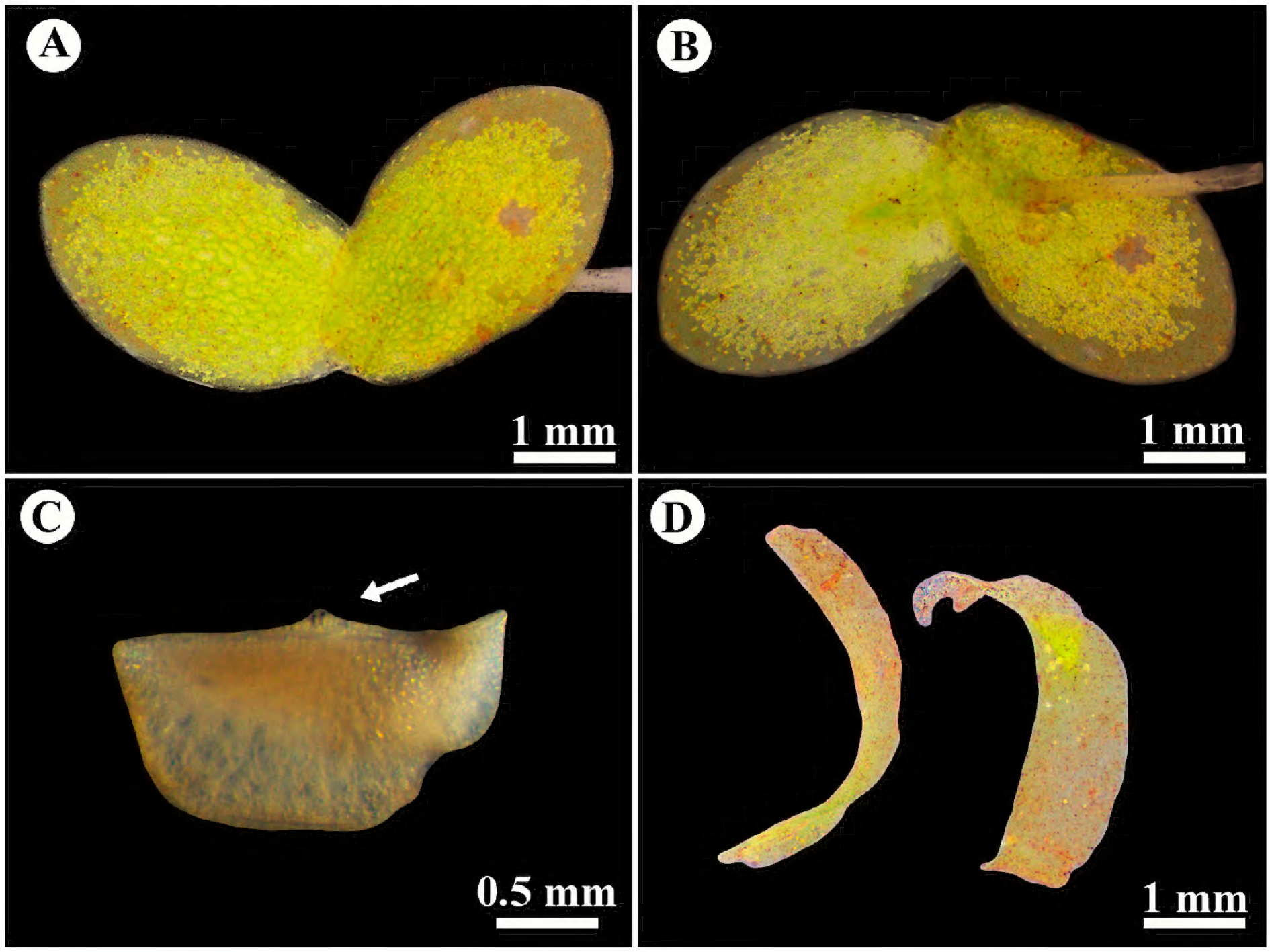


**Figure 2. A, B.** *Lemna valdiviana* Phil. (MAR 11532; 11533). **A.** Adaxial view of the frond. **B.** Abaxial view of the frond. **C.** *Wolffia brasiliensis* Wedd. (MAR 11534; 11535) in lateral view showing the papilla on the adaxial side of the frond (arrow). **D.** *Wolffiella lingulata* (Hegelm.) Hegelm (MAR 11536; 11537) with fronds in lateral view (left) and in abaxial view (right).

as an invasive species—various species of duckweeds are invasive, as in the case of *L. minuta* (Gérard and Triest 2016; Paolacci et al. 2016). *Lemna valdiviana* is not on the IUCN Red List (Maiz-Tome 2016).

According to Pott and Cervi (1999), *L. valdiviana* is found in lentic and shaded environments, covering the surface of water bodies. It is a species with a high protein content and has been considered promising as a food supplement for fish, as well as having potential for phytoremediation of polluted environments (Freitas et al. 2017).

*Wolffia* is characterized by its aquatic habit, absence of roots, with the individuals floating on the water surface or slightly submerged, with one or two fronds that are generally joined and range in shape from globose, conical, cylindrical to ovoid. There is one inflorescence per frond with a single unilocular anther and a globose gynoecium with one ovule, short style, circular stigma and spherical fruit (Bogner 2009; Flora do Brasil 2019). The genus occurs throughout the world, especially in tropical and temperate regions, with centers of diversity in North America (United States and Mexico) and South America (Brazil). In Brazil, the genus occurs in all five major regions with three species: *Wolffia arrhiza* (L.) Horkel ex Wimm., *W. brasiliensis* Wedd., and *W. columbiana* Karsten (Flora do Brasil 2019). Only *W. brasiliensis* is found in Maranhão state.

*Wolffia brasiliensis* occurs from the United States and Mexico to Central and South America, in tropical, subtropica,l and warm temperate regions (Landolt 1986; Tropicos 2019). In Brazil, it is found in the Caatinga, Cerrado, and Atlantic Forest Domains and in the major regions of the North (Amazonas, Pará), Northeast (Alagoas, Bahia, Ceará, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, Sergipe), Midwest (Mato Grosso, Mato Grosso do Sul), South (Paraná, Rio Grande do Sul, Santa Catarina), and Southeast (Espírito Santo, Minas Gerais, Rio de Janeiro, São Paulo) (Coelho 2018; Flora do Brasil 2019). In Maranhão, this species was found in tributaries of the Rio Itapecuru, in the area of influence of the Cerrado, and at the municipalities of of Caxias (Riacho Guarimã) and São João do Sóter (source of the Côrrego do Buriti) (Fig. 1). According to the information available in the Specieslink (2019) database, the records of *W. brasiliensis* in the municipalities of Caxias and São João do Sóter extend its geographic distribution from previously known nearest records, about 860 km to the north (Volta da Serra, Paratinga, Bahia, Brazil), 737 km to the east (Carajás National Forest, Pará, Brazil), and 403 km to the west (Alegrete do Piauí, Piauí, Brazil).

Prior to the records reported here, *W. brasiliensis* had confirmed records for all states of the Northeast Region, except Maranhão. Our new records fill this gap, increase the geographic distribution of this species and confirm also the first record of the genus *Wollffia* in the state of Maranhão (Flora do Brasil 2019).

Although *W. brasiliensis* is more common in rivers, it can also occur on moist soils, in lagoons, shallow floodwaters, disturbed environments, and frequently in eutrophic waters (Pott and Cervi 1999; Trindade et al. 2010). The species can be considered generalist because of the range of environments it can occupy, and it can be used as a bioindicator of water quality and for removing pollution from water (Landolt 1986; Landolt and Kandeler 1987; Pio et al. 2013). Due to the adaptive characteristics of the species, it is not threatened and has the status of Least Concern according to the IUCN classification (Maiz-Tome 2016).

*Wolffiella* is characterized by absence of roots, usually having two fronds joined in a free-floating unit which is submerged just below the water surface. The fronds are thin, flattened, elongated, orbicular to ovate, and linguiform or sometimes falcate. The margin of the fronds is slightly denticulate or smooth, or else with many fronds joined at the vegetative cavity to form a star-shaped colony. The inflorescence cavity contains two flowers and is situated on the dorsal side of the frond, lateral to the median line and near the base, or in *W. welwitschii* there may be two inflorescences in two cavities, one on each side of the median line (Flora do Brasil 2019). *Wolffiella* occurs in North America (United States and Mexico), Central America (Costa Rica, Nicaragua, Panama), and South America (Argentina, Bolivia, Brazil, Chile, Ecuador, Uruguay, Venezuela). There are also records from two African countries: Tanzania and South Africa (Tropicos 2019). It occurs in most states of all five major regions of Brazil, with five species: *W. caudata* Landolt, *W. lingulata* (Hegelm.) Hegelm., *W. neotropica* Landolt, *W. oblonga* (Phil.) Hegelm., and *W. welwitschii* (Hegelm.) Monod (Flora do Brasil 2019).

*Wolffiella lingulata* is distributed in subtropical (with mild winters) and tropical areas of the Americas: United States, Mexico, Panama, Bolivia, Brazil, Argentina, and Uruguay (Tropicos 2019). In Maranhão a single species is found, *W. lingulata*, which has previously confirmed records in the major Brazilian regions of the North (Amazonas, Pará), Northeast (Bahia, Pernambuco and Piauí), Central-West (Mato Grosso and Mato Grosso do Sul), Southeast (Rio de Janeiro), and South (Pott 2002; Pereira et al. 2016; Flora do Brasil 2019). In Maranhão, the species was found in the municipality of Igarapé do Meio, floating on the banks of the Igarapé Puraquéu, a tributary of the Rio Mearim (Correia Filho et al. 2011). It was associated with *Lemna valdiviana*, *Azolla* sp., *Eichhornia crassipes* (Mart.) Solms, *Pistia stratiotes* L., and *Salvinia* sp. This is also the first record of the genus *Wolffiella* for the state of Maranhão (Flora do Brasil 2019).

According to Landolt (1986), *W. lingulata* varies in the length/width ratio of the frond, depending on the climate. In cold climates, the ratio is higher, i.e. relatively narrower fronds, whereas in hot climates the ratio is lower, i.e. the fronds are relatively broader. The Maranhão specimens occur in a hot climate, and thus have lower length/width ratio. This species does not have a conservation status according to the IUCN classification (Maiz-Tome 2016).

Based on the information available in the database Specieslink (2019), the record of *W. lingulata* in the municipality of Igarapé do Meio extends the geographic distribution from the previous nearest records about 814 km to the north (Riacho do Estreito, Lote 02, Pernambuco, Brazil), 368 km to the south (former branch of the Rio Igaraçu, Parnaíba, Piauí, Brazil) and 1,998 km to the east (Amazonas, Brazil) (Fig. 1).

These new records of *Lemna valdiviana*, *Wolffia brasiliensis* and *Wolffiella lingulata* for Maranhão amplify the current knowledge of the geographical distribution of Lemnoideae in northeast Brazil and point to the need to expand floristic studies in Maranhão.

## Acknowledgements

We thank State Secretariat for the Environment and Natural Resources of Maranhão (SEMA), for the authorization of collection in the Baixada Maranhense region (process 16276/2019), to the Maranhão (MAR) and Piauí (HUESPI) herbaria for their support in receiving herbarium specimens for deposit in their collections, and our guide in the field, Mr Arinelson, for his assistance in visiting the Buriti River.

## Authors' Contributions

AWCF, MSO, and WRSJ collected and photographed the plants. AWCF, MSO, WRSJ, IMA and MANC identified and described the specimens. AWCF, MSO, WRSJ, IMA and MANC revised herbarium collections. AWCF, MSO, WRSJ, IMA, MANC and HCO wrote the text. HCO formatted and revised the text. SJM revised the text and the English translation.

## References

Andrade IM, Mayo SJ, Silva MFS, Souza DJL, Matias LQ, Ribeiro TA (2013) The Araceae in Ceará, Brazil: humid forest plants in a semi-arid region. Rodriguésia 64 (3): 445–447.

Appenroth KJ, Borisjuk N, Lam E (2013) Telling duckweeds apart: genotyping technologies for the Lemnaceae. Chinese Journal of Applied Environmental Biology 19 (1): 1–10. https://doi.org/10.3724/SP.J.1145.2013.00001

Angiosperm Phylogeny Group - APG IV (2016) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society 181: 1–20. https://doi.org/10.1111/boj.12385

Armstrong W (2018) Treatment of the Lemnaceae and allies. https://www2.palomar.edu/users/warmstrong/1wayindx.htm. Accessed on: 2019-5-28.

BFG (The Brazil Flora Group) (2015) Growing knowledge: an overview of seed plant diversity in Brazil. Rodriguésia 66 (4): 1085–1113. https://doi.org/10.1590/2175-7860201566411

BFG (2018) Brazilian Flora 2020: Innovation and collaboration to meet Target 1 of the Global Strategy for Plant Conservation (GSPC). Rodriguésia 69 (4): 1513–1527. http://doi.org/10.1590/2175-7860201869402

Bogner J (2009) The free-floating Aroids (Araceae)—living and fossil. Zitteliana series A, 48/49: 113–128.

Boyce PC, Croat TB (2011 onwards) The überlist of Araceae, totals for published and estimated number of species in aroid genera. International Aroid Society. http://www.aroid.org/genera/180211uberlist.pdf. Accessed on: 2019-4-19.

Brummitt RK, Powell CE (1992) Authors of plant names. A list of authors of scientific names of plants, with recommended standard form of their names including abbreviations. Royal Botanic Gardens, Kew, 732 pp.

Cabrera LI, Salazar GA, Chase MW, MayoSJ, Bogner J, D'Ávila P (2008) Phylogenetic relationships of aroids and duckweeds (Araceae) inferred from coding and noncoding plastid DNA. American Journal of Botany 95: 1153–1165. https://doi.org/10.3732/ajb.0800073

Cansanção IF (2008) Relacionamento genético de espécies do gênero *Philodendron* (Araceae, Monocotyledoneae) através da técnica de DAF (DNA Amplification Finger printing). Master dissertation, Universidade Federal de Pernambuco, Recife, 78 pp.

Coelho MAN, Soares ML, Calazans LSB., Gonçalves EG, Andrade IM, Pontes TA, Sakuragui CM, Temponi LG, Buturi C, Mayo S (2015) *Araceae* in Lista de Espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro. http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB51. Accessed on 2019-12-1.

Coelho MAN (2018) Flora das cangas da Serra dos Carajás, Pará, Brasil: Araceae. Rodriguésia 69 (1): 25–40. https://doi.org/10.1590/2175-7860201869103

Coelho MAN (2010) A família Araceae na Reserva Natural Vale, Linhares, Espírito Santo, Brasil. Boletim do Museu de Biologia Mello Leitão 28: 41–87.

Correia Filho FL, Gomes ER, Nunes OO, Filho JBL. (2011). Projeto Cadastro de Fontes de Abastecimento por Água Subterrânea, estado do Maranhão: relatório diagnóstico do município de Igarapé do Meio. CPRM – Serviço Geológico do Brasil, Teresina, 21–22.

Costa CR (1982) A baixada maranhense. Editora Sioge, São Luís, 127 pp.

Daubs EH (1965) A monograph of Lemnaceae. Illinois biological monographs 34. The University of Illinois Press, Urbana 118 pp.

Diário Oficial da União (1953) Lei 1806, de 6 de janeiro de 1953. Seção 1–7/1/1953, 276 pp.

Feitosa AC (2006) Relevo do estado do Maranhão: uma nova proposta de classificação topomorfológica. IV Simpósio Nacional de Geomorfologia, Goiânia, 1–6.

Ferreira AWC, Calio MF, Silva Junior WR, Silva, MJC, Oliveira MS, Silva EO, Guarçoni EAE, Carvalho AKC, Figueiredo N (2018) First record of *Voyria caerulea* Aubl. (Gentianaceae), a mycoheterotrophic plant, in Maranhão state, northeastern Brazil. Check List 14 (5): 833–837. https://doi.org/10.15560/14.5.833

Ferreira AWC, Oliveira MS, Silva EO, Campos DS, Pansarini ER, Guarçoni EAE (2017) *Vanilla bahiana* Hoehne and *Vanilla pompona* Schiede (Orchidaceae, Vanilloideae): two new records from Maranhão state, Brazil. Check List 13 (6): 1131–1137. https://doi.org/10.15560/13.6.1131

Fidalgo O, Bononi VLR. 1989. Técnicas de coleta, preservação de material botânico. Instituto de Botânica, São Paulo, 62 pp.

Flora do Brasil (2019) Flora do Brasil 2020. Lista das espécies da flora do Brasil. Jardim Botânico do Rio de Janeiro. http://floradobrasil.jbrj.gov.br. Accessed on: 2019-8-19.

Freitas RN, Silva MFS, Paiva JS, Mayo SJ, Andrade IM (2017). Taxonomic survey of the Araceae Juss. in the coastal region of Piauí state, northeast Brazil, including the Rio Parnaíba Delta. Iheringia 72 (3): 341–350. https://doi.org/10.21826/2446-8231201772304

Gérard J, Triest L (2016) Competition between invasive *Lemna minuta* and native *L. minor* in indoor and field experiments. Hydrobiologia 812 (1): 57–65. https://doi.org/10.1007/s10750-016-2754-2

Golfari L (1980) Zoneamento ecológico para reflorestamento da área de influência da Serra de Carajás. Revista da Companhia Vale do Rio Doce 1: 8–18.

Grayum MH (1990) Evolution and phylogeny of the Araceae. Annals of the Missouri Botanical Garden 77 (4): 628–697.https://doi.org/10.2307/2399668

Guarçoni EAE, Costa AF, Silva EO, Ferreira AWC, Oliveira MS (2018a) New records of *Tillandsia* L. (Bromeliaceae, Tillandsioideae) from Maranhão state, Brazil. Check List 14 (6): 951–959. https://doi.org/10.15560/14.6.951

Guarçoni EAE, Bastian RE, Silva EO, Ferreira AWC (2018b) First record of the rare *Dyckia racemosa* Baker (Bromeliaceae) in Maranhão state (northeastern Brazil), with an update on the species description, geographic distribution, and conservation status. Phytotaxa 349 (3): 273–280. http://doi.org/10.11646/phytotaxa.349.3.8

Hegelmaier F (1878) Lemnaceae. In: Martius CFP, Eichler AW, Urban I (Eds) Flora brasiliensis. Munchen, Wien, Leipzig 3 (2): 1–24.

Instituto Brasileiro de Geografia e Estatística IBGE (2019) Cidades e estados do Brasil. https://cidades.ibge.gov.br/. Accessed on: 2019-01-21.

IDESP (Instituto de Desenvolvimento Econômico, Social e Ambiental do Pará) (1995) Síntese dos Municípios. IDESP Setor de Coleta e Tratamento de Dados, São Francisco do Pará, 49 pp.

Instituto Maranhense de Estudos Socioeconômicos e Cartográficos (2008) Perfil do Maranhão 2006/2007. IMESC, São Luis,197 pp. http://imesc.ma.gov.br/portal/Post/view/outras-publicacoes/38. Accessed on: 2918-7-18.

Jesus RM, Menandro MS, Thibau CE (1986) Manejo florestal em Buriticupu. In: Anais 1º Simpósio do Trópico Úmido. EMBRAPA/CPATU, Belém, 245–251.

Köppen WP (1948) Climatologia: com um estudio de los climas de la tierra. Fondo de Cultura Econômica, México, 478 pp.

Landolt E (1986) Biosystematic investigations in the family of duckweeds (Lemnaceae) (vol. 2) - The family of Lemnaceae—a monographic study. Volume 1 of the monograph: morphology; karyology; ecology; geographic distribution; systematic position; nomenclature; descriptions. Veröff. Geobot. Inst., series 71, ETH, Stiftung Rübel, Zürich, 566 pp.

Landolt E (1996) Lemnaceae. In: Hunziker AT (Ed.) Flora fanerogámica Argentina. Buenos Aires, Proflora 21: 1–8.

Landolt E, Kandeler R (1987) Biosystematic investigations in the family of duckweeds (Lemnaceae). The family of Lemnaceae—a monographic study v. 2. Geobotanisches Institut der ETH, Zürich 95, 638pp.

Les DH, Crawford DJ, Landolt E, John D, Gabel JD, Rebecca KT (2002) Phylogeny and systematics of Lemnaceae, the duckweed family. Systematic Botany 27 (2): 221–240. https://doi.org/10.1043/0363-6445-27.2.221

Lourenço AR, Bove CP (2019) Flora do Rio de Janeiro: Lemnoideae (Araceae). Rodriguésia 70: 1–15. https://doi.org/10.1590/2175-7860201970042

Maiz-Tome L (2016) *Wolffia brasiliensis*. The IUCN Red List of Threatened Species 2016. http://doi.org/10.2305/IUCN.UK.20161.RLTS.T64326304A67731257.en. Accessed on: 2018-3-13.

Mayo SJ, Bogner J, Boyce PC (1997) The genera of Araceae. Royal Botanic Gardens, Kew, 370 pp.

Moura-Júnior EG, Lima LF, Silva SSL, Paiva RMS, Ferreira FA, Zickel CM, Pott A (2013) Aquatic macrophytes of northeastern Brazil: checklist, richness, distribution and life forms. Check list 9 (2): 298–312. http://doi.org/10.15560/9.2.298

Paolacci S, Harrison S, Jansen MAK (2016) A comparative study of the nutrient responses of the invasive duckweed *Lemna minuta*,

and the native, co-generic species *Lemna minor*. Aquatic Botany 134: 47–53. https://doi.org/10.1016/j.aquabot.2016.07.004

Pereira SF, Pott VJ, Temponi LG (2016) Lemnoideae (Araceae) no estado do Paraná, Brasil. Rodriguésia 67 (3): 839–848. http://doi.org/10.1590/2175-7860201667321

Pio MCS, Souza KS, Santana GP (2013) Capacidade da *Lemna aequinoctialis* para acumular metais pesados de água contaminada. Acta Amazônica 43 (2): 203–210. http://doi.org/10.1590/S0044-59672013000200011

Pott VJ (2002) Lemnaceae. In: Wanderley MGL, Shepherd GJ, Giulietti AM, Melhem TS, Bittrich V, Kameyama C (Eds) Flora fanerogâmica do Estado de São Paulo. Instituto de Botânica, São Paulo, 135–140.

Pott VJ, Cervi AC. (1999) A família Lemnaceae Gray no Pantanal (Mato Grosso e Mato Grosso do Sul), Brasil. Revista Brasileira de Botânica 22 (2): 153–174. http://doi.org/10.1590/S0100-84041999000200007

Silva Junior WR, Fernandes RS, Ferreira AWC (2018) First record of the exotic fern *Pteris tripartita* Sw. (Pteridaceae) for the Maranhão state, northeastern Brazil. Biodiversity International Journal 2 (2): 135–137. https://doi.org/10.15406/bij.2018.02.00055

Silva-Moraes HCI, Cordeiro I, Figueiredo N (2019) Flora and floristic affinities of the Cerrados of Maranhão state, Brazil. Edinburgh Journal of Botany 76 (1): 1–21. https://doi.org/10.1017/S0960428618000215

SpeciesLink (2019) http://www.splink.org.br. Accessed on: 2019-5-2.

Thiers B (2019) Index Herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. https://sweetgum.nybg.org/ih/. Accessed on: 2019-3-2.

Trindade CRT, Pereira AS, Albertoni EF, Palma SC (2010) Caracterização e importância das macrófitas aquáticas com ênfase nos ambientes límnicos do *campus* carreiros – FURG, Rio Grande, RS. Revista Cadernos de Ecologia Aquática 5: 1–22.

Tropicos (2019). Missouri Botanical Garden, Missouri. http://www.tropicos.org/Name/18100014. Accessed on: 19-10-4.